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PLAINS, PLANES, AND PENEPLANES

By DOUGLAS WILSON JOHNSON

Among the landforms which geographers have occasion frequently to describe, none suffers more from the unsatisfactory condition of geographic terminology than do the various types of plains of deposition and plains of erosion. When we realize that the term ''coastal plain'' is used to denote two features of such dissimilar origin as an uplifted series of seabottom deposits and a rock-cut terrace produced by marine abrasion, and that no names have been consistently applied to almost-plane surfaces of marine and aeolian denudation, it must appear desirable to give some attention to the terminology of these all-important forms.

In addition to plains composed of comparatively undisturbed and therefore approximately horizontal stratified rocks, we must recognize (1) the perfectly plane surfaces of ultimate erosion and (2) the imperfect, ''almost-plane'' surfaces which characterize the penultimate stages of the several erosion cycles. Theoretically there may be three, or possibly four, planes of completed erosion, with a corresponding number of almost-plane surfaces of uncompleted erosion, due to the action of rivers, waves, winds, and possibly glaciers.

Davis has given the name ''peneplain'' to the almost-plane surface of uncompleted fluvial denudation. The other almost-plane surfaces remain unnamed, except that such terms as ''plain of marine denudation,'' ''plain of marine abrasion,'' and ''plain of aeolian erosion'' have been applied to erosion surfaces, usually without regard to whether they were really plane surfaces or only surfaces of moderate relief. An exception to the foregoing statement is perhaps to be found in Gulliver's valuable paper on ''Shoreline Topography,'' where he seems to call the almost-plane surface of marine erosion a ''submarine platform,'' although he makes it identical with ''plain of marine denudation'' and would therefore seem to have no name for a perfectly plane surface of marine denudation.[1] It does not seem advisable to apply the adjective ''submarine'' to a surface which is today far above sea level; so some other name should be sought for uplifted surfaces of marine erosion.

It is coming to be recognized that some of the so-called peneplains are more probably almost-plane surfaces of marine erosion, as was, indeed, the opinion of the earlier geologists. Barrell[2] has even questioned the subaerial origin of the New England uplands, supposedly a typical peneplain, and the one above which rises the mountain selected as the type ''monadnock.'' Should his conclusions prove correct and apply to the portion of the supposed peneplain in southern New Hampshire, then not only would the upland cease to merit the term ''peneplain,'' but Mt. Monadnock would no longer be a ''monadnock,'' as that term is generally defined. We would have to change the definition of monadnock or invent a new name for the topographic feature of which it is an example.

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[1] F. P. Gulliver: Shoreline Topography, *Proc. Amer. Acad. Arts and Sciences*, Vol. 34, 1899, pp. 176-177.

[2] Joseph Barrell: Piedmont Terraces of the Northern Appalachians and Their Mode of Origin, *Bull. Geol. Soc. Amer.*, Vol. 24, 1913, p. 690.

It appears, therefore, that we need names for the different types of erosion surfaces, which theoretically may be produced, both in the penultimate and the ultimate stages of erosion; that we also need a name for the actually existing upland surfaces of erosion which are so abundant in different parts of the world but of whose origin we are not yet certain; and, finally, that we need a clearer distinction in the names themselves, between ''plains'' of erosion, ''plains'' of deposition, and ''peneplains.'' The writer believes it is possible to meet all these needs without departing unduly from the path of conservatism; and to this end the following usage is suggested: (1) The level erosion surface produced in the ultimate stage of any cycle may be called a *plane.* (2) The undulating erosion surface of moderate relief produced in the penultimate stage of any cycle may be called a *peneplane.* (3) A low-relief region of horizontal rocks would, as now, be called a *plain.* We should then recognize planes of fluvial,[3] marine, aeolian, and glacial denudation; also fluvial peneplanes, marine peneplanes, aeolian peneplanes, and glacial peneplanes. A monadnock would be defined as an erosion remnant left standing above a peneplane of any origin, either because it is composed of more resistant rock or because it has been less exposed to the agents of erosion. Vogt[4] has already used the term ''Monadnock-Berge'' for isolated hills on the uplifted marine abrasion plane of northern Norway. It seems desirable to employ a special term for a surface of marine denudation which is still in its original position at or near wave base, with the marine forces still operating on it, and for this feature the name ''abrasion platform'' has already been used. An uplifted abrasion platform of large areal extent is a marine peneplane or a marine plane, according to the smoothness of the surface produced by wave erosion.

The advantages of the suggested usage are obvious. It tends to simplify, not to complicate physiographic terminology. The origin of any of the level or almost-level surfaces here discussed is at once apparent from the spelling. If one uses the otherwise noncommittal term ''marine plain'' in the manner here suggested, the reader knows at once that a plain of marine sediments is referred to; while ''marine plane'' indicates a wave-cut plane surface. When we remember that both of these forms have been called ''marine plains,'' the advantage of the distinction in spelling is evident. One of our ablest physiographers has applied to a wave-cut rock bench along the coast, the term ''coastal plain.'' Had he written ''coastal plane,'' his meaning at least would have been clear, even though the term as a whole might still be criticized. A peneplain is not ''almost a plain'' of horizontal sediments but is almost a plane surface in the mathematical sense of the term; therefore ''peneplane'' more clearly expresses the true meaning of the term than does the older and commoner spelling. So standard a text as Dana's ''Manual of Geology''[5] employs the spelling ''peneplane;'' while J. W. Gregory in his recent book on ''The Nature and Origin of Fiords,''[6] makes use of the same form. Lawson has employed both spellings, the form ''peneplane'' occurring in his ''Post-Pliocene Diastrophism of the Coast of Southern California.''[7] It may be, also, that the combination of ''plane'' with ''pene-'' will seem less objectionable to those who dislike hybrid terms, since ''plane'' is closer to the original Latin form than ''plain.''

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[3] "Subaerial" denudation was long used for "fluvial" denudation, because of the prevalent idea that there were only two important types of denudation, subaerial and submarine. Since the importance of aeolian denudation, which is also subaerial, has been recognized, it is desirable to distinguish the two types of subaerial denudation by the terms "fluvial" and "aeolian."

[4] J. H. L. Vogt: Über die schräge Senkung und die spätere schräge Hebung des Landes im nördlichen Norwegen, *Norsk Geologisk Tidsskrift,* Vol. 1, 1907, p. 17.

Davis' introduction of ''peneplain'' into the vocabulary of physiography in 1889[8] was a valuable service to the science; for it led to a speedy and worldwide recognition of a conception which had previously been announced but which did not become current until well named. It should be appreciated, however, that at this time the idea of subaerial denudation was supplanting, rather than supplementing, the idea of marine denudation. The general attitude was well expressed by De Lapparent in the words: ''La notion des pénéplaines est extrêmement féconde, et ce n'est pas un de ses moindres mérites d'avoir porté le coup de grâce à la théorie des plaines de dénudation marine, si fort en honneur de l'autre côté du détroit.''[9] Davis himself regarded extensive planes of marine denudation as ''very improbable,''[10] while planes of glacial or aeolian denudation were as yet scarcely considered. All planes of penultimate stages of erosion were called ''peneplains'' because it was believed that they were all formed essentially by subaerial agencies. No need was felt of names for almost-plane surfaces of marine and other types of erosion, since the existence of such planes was either considered improbable or was not considered at all.

Later years have witnessed the publication of Passarge's studies of surfaces of aeolian denudation,[11] and the probability of the existence of fairly extensive surfaces of marine denudation seems now to be recognized by Davis and others.[12] We are confronted with the fact that there are numerous almost-plane erosion surfaces in various parts of the world, the origin of which is in most cases doubtful and in many cases will probably never be known because nearly all of the upland has been destroyed by subsequent stream erosion. As Davis once remarked, "It must be remembered that the terms 'plain of marine denudation' and 'peneplain' are in nearly all cases hardly more than different names for the same thing. If the whole truth were known, it is probable that one or the other name might be appropriately applied in this or that case, but it is seldom that anyone has succeeded in convincing all his contemporaries that he could distinguish a plain of marine denudation from a peneplain, or vice versa."[13] Present needs can better be met by applying the excellent term "peneplane" to all these surfaces and qualifying the term by the word fluvial, marine, aeolian, or glacial in case it can be shown that a given surface is of the origin indicated by the qualifier, rather than by inventing a new term for almost-plane erosion surfaces of doubtful origin. Peneplane is too valuable a term and is too extensively used to have it restricted to the very few (if any) erosion surfaces demonstrably of fluvial origin; and, since the wise physiographer avoids a name which commits him unwillingly to a certain theory of origin, it seems best in the present case to extend the meaning of the term.

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[5] J. D. Dana: Manual of Geology, 4th edit., 1895, p. 204.

[6] J. W. Gregory: The Nature and Origin of Fiords, London, 1913, p. 195.

[7] A. C. Lawson: The Post-Pliocene Diastrophism of the Coast of Southern California, *Bull. Univ. of California Dept. Geology*, Vol. 1, 1893, p. 158.

[8] W. M. Davis: Topographic Development of the Triassic Formation of the Connecticut Valley, *Amer. Journ. Sci.*, 3rd Ser., Vol. 37, 1889, p. 430.

[9] La geomorphogénie, *Rev. des Quest. Scient.*, 1895.

[10] W. M. Davis: Geographical Essays, edited by Douglas W. Johnson, Boston, 1909, p. 291.

[11] Siegfried Passarge: Die Kalahari, 822 pp., Berlin, 1904; Rumpffläche und Inselberge, *Zeitschr. Deutsch. Geol. Gesell.*, Vol. 56, 1904, Protokoll, pp. 193-209; Die Inselberglandschaften im tropischen Afrika, *Naturwiss. Wochenschr.*, N. S., Vol. 3, 1904, pp. 657-665.

While it is true that the writer is advocating a broader significance for "peneplane" than is usually given to it, precedent for such usage is not altogether lacking. H. E. Gregory is responsible for using the term as synonymous with "plain of denudation . . . . carved out of other landforms either by the action of the forces that work on the land or by the waves of the sea."[14] Davis himself has occasionally employed the term in the broader sense. Thus, in an account of the geographic development of northern New Jersey, he discusses at length "whether the old Highland peneplain was the product of subaerial or submarine processes."[15] He distinguishes between "subaerial baselevel plain" and "submarine platform" but applies the name "peneplain" to the topographic feature itself, while its origin remains in doubt. In a discussion of the arid cycle by the same author,[16] "peneplains" are usually contrasted with true "plains" of aeolian erosion; but the frequent use of the expression "normal peneplain" and the application of the term "monadnock" to residuals on a plane of aeolian denudation suggest that the author at least unconsciously recognized the possible existence of peneplanes which were not formed by ''normal'' (stream) erosion. Marine peneplanes are more definitely recognized, at least as a theoretical possibility requiring discussion, when in an essay on planes of marine and subaerial denudation the author says: ''By whatever process the so-called 'plain of denudation' was produced, an explanation that will account for a peneplain of moderate or slight relief is all that is necessary.''[17]

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[12] W. M. Davis: Meandering Valleys and Underfit Rivers, *Annals Assoc. Amer. Geogrs.*, Vol. 3, 1913, p. 27.
Idem, op. cit. sub 10, p. 374.
Joseph Barrell: *op. cit.*, p. 690.

[13] *Op. cit.* sub 10, p. 374.

[14] H. E. Gregory, A. G. Keller, and A. L. Bishop: Physical and Commercial Geography, Boston, 1910, p. 46.

[15] W. M. Davis and J. W. Wood: The Geographic Development of Northern New Jersey, *Proc. Bost. Soc. Nat. Hist.*, Vol. 24, 1890, p. 374.

[16] *Op. cit.* sub 10, pp. 276-322.

It appears, therefore, that many considerations of weight favor a more general adoption of the spelling ''peneplane'' and the employment of the term to designate almost-plane surfaces produced in the penultimate stage of any erosion cycle. Should these considerations, as set forth above, commend themselves favorably to others, the writer suggests that they adopt the usage advocated and thereby assist in simplifying and clarifying physiographic terminology. Every extension of this usage, already established in certain quarters, will serve to render more precise the important conceptions for which the words plain and peneplane now stand.

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[17] *Ibid.*, p. 340.